

REMARKS

Rejections under 35 USC §103(a)

Claims 1-5 are rejected under 35 USC §103(a) as being obvious over Takada et al. (WO 01/182276) in view of Fukasawa et al. (U.S. Patent No. 4,514,234).

Claim 1, as amended, recites, among other things, “at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed in said molybdenum matrix;” and “wherein said nitride particles are dispersed by internally nitriding a worked molybdenum-alloy material in which a nitride-forming-metal element is dissolved forming a solid solution in a molybdenum matrix and at least one of carbide particles, oxide particles, and boride particles is precipitated and dispersed.” Amended claim 1 further recites “wherein a worked crystal-grain structure or a recovered crystal-grain structure is maintained in both surface region and inner region of the worked molybdenum-alloy material, and the worked molybdenum-alloy material has a recrystallization temperature of 1800 °C or higher.”

Fukasawa et al described as follows:

In addition to the dopants described above, the recrystallized grains constituting the molybdenum board of the present invention preferably contain 0.3 to 3% by weight of one or more compounds (to be referred to as additives hereinafter) selected from the group consisting of oxides, carbides, borides and **nitrides** of La, Ce, Dy, Y, Th, Ti, Zr, Nb, Ta, Hf, V, Cr, Mo, W and Mg. When such compound or compounds are uniformly dispersed in the molybdenum grains, the strength of the molybdenum board at high temperatures is improved.

(Fukasawa et al, column 2, lines 35-44). Thus, in Fukasawa et al, nitrides are treated the same as oxides, carbides, and borides. Takada et al describes as follows:

The present invention also provides a manufacturing method of a high toughness, high strength, refractory-metal-based alloy material of a nitride particle dispersed type, comprising the steps of: preparing an alloy worked piece having a parent phase consisting of one element selected from Mo, W and Cr, wherein a nitride-forming metal element consisting of at least one element selected from Ti, Zr, Hf, V, Nb and Ta is incorporated into the alloy worked piece as a solid solution; heating the alloy worked piece in the range of a temperature lower than a recrystallization lower limit temperature the alloy worked piece by 200°C. to a recrystallization upper limit temperature of the alloy worked piece under nitriding atmosphere to disperse ultra-fine nitride particles of the nitride-forming metal element, as a first nitriding treatment; and heating the first resulting alloy worked piece obtained from the first nitriding treatment at a temperature equal to or higher than a recrystallization lower limit temperature of the first resulting alloy worked piece under nitriding atmosphere to grow and stabilize the dispersed ultra-fine nitride particles by the first nitriding treatment, as a second nitriding treatment.

(Takada et al column 3, lines 47-67). Thus, according to Takada et al, an alloy worked material has a matrix consisting of one element selected from Mo, W and Cr, wherein a nitride-forming metal element consisting of at least one element selected from Ti, Zr, Hf, V, Nb and Ta is incorporated into the alloy worked piece as a solid solution. The worked material of Takada et al does not include “at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed in said molybdenum matrix.”

As explained in the present specification at page 4, TZM alloy includes carbide particles, oxide particles precipitated and dispersed in molybdenum. In TZM alloy (for example, Mo-

Ti(0.5)-Zr(0.08)-C(0.03)), fine-grained carbide particles such as (Ti, Zr)C contribute to the fairly high recrystallization temperature of about 1300°C to about 1400°C, and excellent strength at 1100°C or less.

Similarly, according to the present invention, the worked alloy material includes “at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed in said molybdenum matrix.” Therefore, because at least one of carbide particles, oxide particles, and boride particles are already precipitated and dispersed in said molybdenum matrix, a person of ordinary skill in the art would consider that additional precipitation of nitride particles will be just redundant to contribute to the heat resistance and would not expect significant improvement of heat resistance.

Therefore, there is no reason for a person of ordinary skill in the art to add precipitation of nitride particles to the worked material including at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed.

The present inventors discovered that the heat resistance is further remarkably improved by the additional precipitation of fine nitride particles in the worked material including at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed therein.

As already mentioned, TZM alloy (for example, Mo-Ti(0.5)-Zr(0.08)-C(0.03)) that contains fine-grained carbide particles such as (Ti, Zr)C has a recrystallization temperature of about 1300°C to about 1400°C. However, the TZM alloys cannot be used at 1500°C or more because recrystallization occurs to cause embrittlement.

In contrast, the present inventors found that the recrystallization temperature of the material subjected to the nitriding step can be significantly increased to 1800°C or more while the recrystallization temperature of the untreated TZM alloy was 1300°C. Consequently, the nitriding step has the effect of significantly increasing the recrystallization temperature at least 500°C higher than the recrystallization temperature of the untreated TZM alloy.

These results could not have been expected by a person of ordinary skill in the art before the present invention.

Moreover, it should be noted that a recrystallized structure is different from a recovered structure. Recovery takes place without recrystallizing below the recrystallization temperature. Takada et al describes as follows:

In the second or subsequent nitriding treatment, the particles precipitated in the surface region of the alloy worked piece are grown and stabilized with keeping the worked structure of the diluted alloy worked piece. **The inside of the alloy worked piece is recrystallized at this nitriding temperature.**

(Takada et al, column 4, lines 49-54). Thus, according to Takada et al, the inside of the alloy worked piece is recrystallized at the nitriding temperature. Takada et al describes in Example 2 as follows:

A TZM alloy worked piece (commercially available from Plansee Co., composition: Mo-0.5Ti-0.08Zr-0.03C) was subjected to the first nitriding treatment at 1200°C. for 24 hours, and then subjected to the second nitriding treatment at 1600°C. for 24 hours. FIG. 8 is an optical microphotograph showing the section of the worked piece. The temperature in the first nitriding treatment can be raised up because of high recrystallization temperature of the TZM alloy. It can be seen that the worked structure is maintained from the surface to a depth of about 300µm.

(Takada et al, column 8, lines 44-53). The temperature of the second nitriding treatment at 1600°C is above the recrystallization temperature. This corresponds to Comparative Example 1 in the present application. Because the alloy worked piece is treated above the recrystallization temperature, the inside of the alloy worked piece is recrystallized. Therefore, the nitrided alloy work piece does not have a worked crystal-grain structure of a recovered crystal-grain structure.

According to the present invention, the molybdenum-alloy material has higher recrystallization temperature of 1800 °C or higher because the molybdenum matrix contains a nitride forming element dissolved therein forming a solid solution, and at least one of carbide particles, oxide particles, and boride particles is precipitated and dispersed in the molybdenum matrix. This makes it possible to maintain a worked crystal-grain structure or a recovered crystal-grain structure in both surface region and inner region of the worked molybdenum-alloy material.

Due to the crystal-grain structure different from the conventional worked molybdenum-alloy material, the worked molybdenum-alloy material of the present invention has high strength and high toughness.

For at least these reasons, claim 1 patentably distinguishes over Takada et al and Fukasawa et al. Claims 2-4, depending from claim 1 also patentably distinguishes over Takada et al and Fukasawa et al for at least the same reasons.

Similarly, claim 5 recites “preparing a worked molybdenum-alloy material comprising a molybdenum matrix, at least one of carbide particles, oxide particles, and boride particles precipitated and dispersed in said molybdenum matrix, and at least one of titanium, zirconium,

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hafnium, vanadium, niobium, and tantalum dissolved in said molybdenum matrix forming a solid solution.”

For similar reasons, claim 5 patentably distinguishes over Takada et al and Fukasawa et al.

In view of the aforementioned amendments and accompanying remarks, Applicants submit that the claims, as herein amended, are in condition for allowance. Applicants request such action at an early date.

If the Examiner believes that this application is not now in condition for allowance, the Examiner is requested to contact Applicants’ undersigned attorney to arrange for an interview to expedite the disposition of this case.

If this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. The fees for such an extension or any other fees that may be due with respect to this paper may be charged to Deposit Account No. 50-2866.

Respectfully submitted,

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